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(54) **Fuel system for an internal combustion engine**

Kraftstoffsystem für eine Brennkraftmaschine

System d'injection d'un moteur à combustion interne

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Description

Technical Field

[0001] This invention relates generally to fluid systems for internal combustion engines, and more particularly to a high pressure rail assembly of a fuel system of an internal combustion engine.

Background

[0002] Two common types of fuel systems for internal combustion engines include hydraulically-actuated-electronically-controlled unit injector type fuel systems and common rail type fuel systems. In some hydraulically-actuated-electronically-controlled unit injector type fuel system, working fluid, such as hydraulic oil, is supplied from a high pressure pump to two high pressure rails or collection chambers. The high pressure rails are connected to the fuel injectors of the fuel system and deliver the high pressure working fluid to a fuel injector upon actuation of the injector. The high pressure working fluid enters the fuel injectors and urges an intensifier piston of the injector to pressurize fuel located in a fuel chamber of the fuel injector. The pressurized fuel then exits the tip of the injector into a combustion chamber of the engine. U.S. Patent No. 5,168,855 to Dwight V. Stone discloses a hydraulically-actuated-electronically-controlled unit injector type fuel system including two high pressure rails.

[0003] Similar to the hydraulically-actuated-electronically-controlled unit injector type fuel systems, some common rail fuel systems include two high pressure rails supplying working fluid to the fuel injectors. In this system, however, the working fluid is pressurized fuel. Accordingly, the fuel injectors do not include an intensifier piston, but rather perform essentially as a gate for supplying the pressurized fuel from the high pressure rails to the combustion chambers of the engine.

[0004] Maintaining the pressure of the fluid in the high pressure rails as constant as possible is a requirement for efficient engine operation of both the hydraulically-actuated-electronically-controlled unit injector and common rail type fuel systems. The amount of fuel that is injected into a combustion chamber by a fuel injector is directly dependent on the pressure of the working fluid in the high pressure rails. Accordingly, pressure fluctuations in the high pressure rails can cause the fuel injector to inject more or less fuel than is needed by the engine, thus detrimentally affecting engine performance.

[0005] One problem in maintaining consistent fluid pressure in the high pressure rail is the fact that each injection event inherently causes a quick drop in the fluid pressure of a high pressure rail because working fluid from the rail quickly exits the rail and flows into a fuel injector. Even further, the pressure fluctuations caused by one injection event can join with pressure fluctuations caused by previous or subsequent injection events to intensify the pressure fluctuations. Further, these pressure fluctuations may include peak pressures that can stress the components of the high pressure rail and thereby affect the design requirements of the fuel system.

[0006] U.S. Patent No. 5,168,855 provides a system that reduces pressure fluctuations in a hydraulically-actuated-electronically-controlled unit injector type fuel system having two high pressure fluid rails. The ’855 patent discloses one high pressure rail on each side of the engine. A Helmholz resonance isolation type valve is located in the lines connecting each high pressure rail to a high pressure pump. The Helmholz resonance isolation type valve includes a one-way check valve and an orifice in parallel flow communication. The Helmholz type valve acts to limit pressure fluctuations from flowing from one high pressure rail to the other high pressure rail. One drawback feature of the fuel system of the ’855 patent is that the pressure fluctuations caused by a fuel injector on one side of the engine are not isolated from the other injectors located on the same side of the engine.

[0007] Further, DE 101 14 219 A shows a fuel injection system having a high pressure pump via which fuel injectors are supplied. In particular, the system has a high pressure pump supplying fuel at high pressure via a single control block, a plurality of supply line sections and a corresponding number of storage volumes to a corresponding number of fuel injectors. The storage volumes are arranged immediately before each corresponding fuel injector. The storage volumes for the fuel injectors are supplied directly with high pressure fuel by the high pressure pump.

[0008] The present invention intends to provide a fuel system for an internal combustion engine that avoids some or all of the aforesaid shortcomings in the prior art.

Summary of the Invention

[0009] In accordance with the present invention, a fuel system and a method for reducing pressure fluctuations in a fuel system as set forth in claims 1 and 9, respectively, are provided. Further embodiments of the invention are claimed in the dependent claims.

[0010] In accordance with one aspect of the invention, a fuel system for an internal combustion engine includes at least four fuel injectors for supplying fuel to corresponding combustion chambers of the engine, and a pump in fluid communication with the fuel injectors and supplying working fluid to the fuel injectors. The fuel system further includes at least three high pressure rails fluidly connected between the pump and the at least four fuel injectors.

[0011] According to another aspect of the present invention, a method for reducing pressure fluctuations in a fuel system of an internal combustion engine includes supplying working fluid from a high pressure pump to at least three high pressure rails, and supplying fuel injectors of the engine with working fluid from the at least three high pressure rails.

[0012] According to yet another aspect of the present invention, a method for supplying working fluid to a group of fluid control valves of an internal combustion engine includes supplying working fluid from a high pressure pump to at least a first, second and third high pressure rail. The method further includes passing working fluid from the first high pressure rail through a fluid control valve of a first group of fluid control valves, passing working fluid from the second high pressure rail through a fluid control valve of a second group of fluid control valves after said passing of working fluid through a fluid control valve of the first group of fluid control valves, and passing working fluid from the third high pressure rail through a fluid control valve of a third group of fluid control valves after said passing of working fluid through a fluid control valve of the second group of fluid control valves.

Brief Description of the Drawings

[0013]

FIG. 1 is a schematic illustration of a portion of a fuel system of an internal combustion engine according to the disclosure;

FIG. 2 is a schematic illustration of a portion of an alternative arrangement of a fuel system of an internal combustion engine according to the disclosure;

FIG. 3 is a schematic illustration of a portion of another alternative arrangement of a fuel system of an internal combustion engine according to the disclosure;

FIG. 4 is a schematic illustration of a portion of yet another alternative arrangement of a fuel system of an internal combustion engine according to the disclosure; and

FIG. 5 is a schematic illustration of a portion of still another alternative arrangement of a fuel system of an internal combustion engine according to the disclosure.

Detailed Description

[0014] Reference will now be made in detail to the drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0015] FIG. 1 illustrates a fluid circuit 10 for a fuel system of an internal combustion engine. The fluid circuit 10 may provide high pressure hydraulic fluid, such as hydraulic oil or engine oil, to hydraulically actuated unit fuel injectors 12 in an arrangement commonly referred to as a hydraulically-actuated-electronically-controlled unit injector type fuel system. Alternatively, fluid circuit 10 may provide high pressure fuel to the fuel injectors 12 in accordance with an arrangement typically referred to as a common rail type fuel system. The fluid utilized in the fluid circuit 10, be it hydraulic oil, engine oil or fuel, will hereinafter be generically referred to as working fluid.

[0016] Fluid circuit 10 may include a source of low pressure working fluid 14, for example, the engine's lubricating oil sump or the engine's fuel tank. A supply pump 16 may be fluidly connected through a low pressure supply line 18 to supply working fluid to a high pressure pump assembly 20. Pump assembly 20 may be of any common type, such as an axial piston pump or radial piston pump. Further, the high pressure pump assembly 20 may be of the variable displacement type, fixed displacement type, or of the fixed displacement, variable delivery type. Also, the high pressure pump assembly 20 may include a single pump unit or multiple pump units.

[0017] An outlet of pump assembly 20 is connected to two high pressure working fluid supply lines 22, 24, each of which are fluidly connected at opposite sides of the engine to high pressure rails 26, 28, 30, 32. The high pressure rails 26, 28, 30, 32 as described herein include collection chambers separate from the high pressure working fluid supply lines 22, 24 that receive and store a volume of working fluid to be delivered to the fuel injectors 12 upon actuation of the fuel injectors 12.

[0018] Reference will now be made to the components of a single high pressure rail 26, with the understanding that similar components are associated with the remaining high pressure rails 28, 30, 32. The high pressure rail 26 may include a series of branches 34 fluidly connecting the high pressure rail 26 to a series of the fuel injectors 12. As shown in Fig. 1, the high pressure rail 26 may include five branches 34, each connecting to one of five fuel injectors 12. Each fuel injector 12 includes a fluid control valve 35 for controlling the passing of working fluid from the high pressure rail 26 through the branch 34 and into the fuel injector 12. The fluid circuit 10 further includes a return line 36 connecting the fuel injectors 12 back to the source of low pressure working fluid 14.

[0019] The fuel system shown in Fig. 1 includes a total of twenty fuel injectors 12, thus forming a V-20 engine. As noted above, two high pressure rails 26, 28 may be formed on one side of the engine, and two other high pressure rails 30, 32 may be located on the other side of the engine. In accordance with the present disclosure, more high pressure rails may be located on each side of the engine. For example, the V-20 engine may include as many as five high pressure fluid rails located on each side of the engine, with each rail being connected to an equal or unequal number of fuel injectors 12.

[0020] Referring again to Fig. 1, each high pressure working fluid supply line 22, 24 is connected to a common outlet of the high pressure pump assembly 20. Each supply line 22, 24 further includes a common supply line portion 40, 42 located between the high pressure pump assembly 20 and a split 44, 46. Individual supply line portions extend from the split 44, 46 to each individual high pressure rail 26, 28, 30, 32. Accordingly, the rails 26, 28 and 30, 32 located on each side of the engine are only fluidly connected to one another via the common supply line portions 40 and 42. Alternatively, common supply line portions 40 and 42 may be arranged to fluidly connect high pressure rails located on opposite sides of the engine.

[0021] Fig. 2 shows an alternative arrangement for the fuel system described above with respect to Fig. 1. The fluid circuit 50 of Fig. 2 may include all of the aspects described above regarding the fluid circuit 10 of Fig. 1, except for the addition of a bridge line 52, 54 fluidly connecting adjacent high pressure rails 26, 28 and 30, 32 located on each side of the engine. Each bridge line 52, 54 may include an orifice 56, 58 providing a fixed flow restriction between the adjacent high pressure rails 26, 28 and 30, 32 on each side of the engine. Alternatively, bridge lines 52, 54 may extend between high pressure rails located on opposite sides of the engine.

[0022] Fig. 3 shows an alternative arrangement for the fuel system described above with respect to Fig. 1. The fluid circuit 60 of Fig. 3 may include all of the aspects described above regarding the fluid circuit 10 of Fig. 1, except for the addition of a Helmholz bridge forming a fluid connection between at least two high pressure rails 26, 28, 30, 32. The Helmholz bridge may include two Helmholz resonance isolation valves 62, 64 and 66, 68 connecting adjacent high pressure rails 26, 28 and 30, 32 on each side of the engine. As shown schematically in Fig. 3, each Helmholz resonance isolation valve 62, 64, 66, 68 may include a one-way check valve 70 and an orifice 72 connected in parallel to the check valve 70. The orifice 72 may be formed as an orifice extending through the check of the check valve 70 or, as shown in Fig. 3, as a separate flow passage around the one-way check valve 70. Further, the two Helmholz resonance isolation valves 62, 64 and 66, 68 may share a single orifice. The adjacent Helmholz resonance isolation valves 62, 64 and 66, 68 on each side of the engine may include oppositely oriented check valves 70 to allow fluid communication in both directions between the adjacent high pressure rails 26, 28 and 30, 32. It is understood that the Helmholz resonance isolation valves 62, 64 and 66, 68 may be configured to extend between high pressure rails located on opposite sides of the engine. Further, the fluid connection formed by each Helmholz bridge may include one or more conduits extending from the connected high pressure rails. Fig. 2 illustrates Helmholz bridges with two conduits extending from each high pressure rail.

[0023] Fig. 4 shows another alternative arrangement for the fuel system described above with respect to Fig. 1. The fluid circuit 80 of Fig. 4 may include all of the aspects described above regarding the fluid circuit 10 of Fig. 1, except for the addition of Helmholz resonance isolation valves 82, 84 connected to each high pressure supply line 22, 24 adjacent the outlet of the high pressure pump assembly 20. As described above with respect to the arrangement of Fig. 3, each Helmholz resonance isolation valve 82, 84 may include a one-way check valve 86 and an orifice 88 formed parallel to the check valve 86. The orifice 88 may be formed as an orifice extending through the check of the check valve 86 itself or, as shown in Fig. 4, as a separate flow passage around the one-way check valve 86. Each of the check valves 86 are oriented to prohibit fluid flow from the high pressure rails 26, 28, 30, 32 back to the high pressure pump assembly 20.

[0024] Fig. 5 shows yet another alternative arrangement for the fuel system described above with respect to Fig. 1. The fluid circuit 90 of Fig. 5 may include all of the aspects described above with respect to the fluid circuit 10 of Fig. 1, except that the high pressure supply lines 22, 24 are replaced with individual supply lines 92, 94, 96, 98 extending from the outlet of the high pressure pump assembly 20 to each high pressure rail 26, 28, 30, 32.

[0025] It is understood that features of the different fuel systems 10, 50, 60, 80 and 90 of Figs. 1-5 may be combined to form alternative fuel systems. For example, the bridge lines 52, 54 of Fig. 2 or the Helmholz bridges of Fig. 3 may be included in the fuel systems of Figs. 1, 4 and 5 to provide a fluid connection between two high pressure rails. Further, the Helmholz resonance valves 82 and 84 of the fuel system of Fig. 4 may be included in each of the high pressure supply lines 92, 94, 96 and 98 of the fuel system of Fig. 5.

Industrial Applicability

[0026] Referring now to the operation of the fluid circuit 10 of Fig. 1, supply pump 16 draws working fluid from the source of low pressure working fluid 14 and delivers the working fluid through the low pressure supply line 18 to high pressure pump assembly 20. High pressure pump assembly 20 then pressurizes the working fluid and supplies the pressurized working fluid through the high pressure working fluid supply lines 22, 24 to the high pressure rails 26, 28 and 30, 32 located on each side of the engine. Actuation of an individual fuel injector 12 is initiated by opening the fluid control valve 35 of the fuel injector 12 to allow working fluid to flow or pass through the branch 34 located between the fuel injector 12 and its respective high pressure rail 26, 28, 30, 32, and into the individual fuel injector 12.

[0027] In a hydraulically-actuated-electronically-controlled unit injector type fuel system, the working fluid entering the fuel injector 12 acts on an intensifier piston (not shown) to pressurize fuel in a fuel chamber (not shown) of the fuel injector and inject the pressurized fuel into a combustion chamber (not shown) of the engine. Alternatively, in a common rail fuel system, the high pressure rails 26, 28, 30, 32 supply pressurized fuel to the fuel injectors 12, and upon actuation of a fuel injector 12, the fuel thereafter travels through the injector and is injected into a combustion chamber of the engine. The injectors may be coupled to the source of low pressure working fluid 14 thorough return lines 36 so as to drain the bypass flow from the fuel injectors 12.

[0028] The timing and duration of the actuation of each fuel injector 12 is determined by the control system of the engine (not shown), as is known in the art. The actuation timing and duration may vary based on a number of sensed engine conditions, such as engine load, engine temperature, engine crankshaft position, and fluid pressure in the high pressure rails, 26, 28, 30, 32. The fluid pressure in the high pressure rails 26, 28, 30, 32, however, may fluctuate as a result of the supplying of working fluid to the fuel injectors 12 upon actuation of a fuel injector 12. The use of at least two separate high pressure rails 26, 28 and 30, 32 on each side of the engine, in accordance with the present disclosure, minimizes the effects of the pressure fluctuations by partially isolating the pressure fluctuations created in one high pressure rail 26, 28, 30, 32 from the remaining high pressure rails 26, 28, 30, 32. The use of four separate high pressure rails reduces the number of fuel injectors 12 coupled to a high pressure rail, and thus reduces the influence of a fuel injector actuation on the remaining fuel injectors 12. Accordingly, pressure fluctuations caused by one high pressure rail 26, 28, 30, 32 must travel from the high pressure rail 26, 28, 30, 32 along the high pressure working fluid supply lines 22, 24, to the split 46 of the supply line 22, 24 and then to the adjacent high pressure rail 26, 28, 30, 32 before affecting the adjacent high pressure rail 26, 28, 30, 32.

[0029] Pressure fluctuations of the working fluid are further reduced when the firing order of the fuel injectors 12 is selected so that actuation of a fuel injector 12 associated with a particular high pressure rail 26 is separated from actuation of another fuel injector 12 associated with the same high pressure rail 26. As noted above, actuation of a fuel injector 12 is initiated by opening the fluid control valve 35 of the fuel injector 12 so that working fluid passes from a respective high pressure rail 26, 28, 30, 32, through the corresponding branch 34, and into the fuel injector 12. The maximum separation of injection events in a high pressure rail is achieved by serially alternating actuation of a fuel injector 12 between each of the high pressure rails 26, 28, 30, 32. Such a firing order is shown in Fig. 1 by the circled numbers 1-20.

[0030] Fluid circuit 50 illustrated in Fig. 2 operates in generally the same manner as the fluid circuit 10 of Fig. 1, except that the bridge lines 52, 54 allow additional fluid flow between adjacent high pressure rails 26, 28 and 30, 32 located on the same side of the engine. The orifices 56, 58, however, restrict the amount of fluid communication between adjacent high pressure rails 26, 28 and 30, 32 so that large pressure fluctuations are not transferred between the rails. The limited fluid communication between adjacent high pressure rails 26, 28 and 30, 32 provides for a less rigid fluid circuit 50, thereby allowing pressure fluctuations in the high pressure rails 26, 28, 30, 32 to dissipate faster.

[0031] Fluid circuit 60 illustrated in Fig. 3 operates in a similar manner to the fluid circuit 10 of Fig. 1, except for the additional fluid communication between adjacent high pressure rails 26, 28 and 30, 32 provided by the Helmholz resonance isolation valves 62, 64 and 66, 68 between adjacent high pressure rails 26, 28 and 30, 32. The check valves 70 of the Helmholz resonance isolation valves 62, 64 and 66, 68 provide greater communication between adjacent high pressure rails 26, 28 and 30, 32 when pressure fluctuations in a high pressure rail 26, 28, 30, 32 reach above a predetermined magnitude. The predetermined magnitude is a function of the force biasing the check of the check valve 70 in its closed position. Thus, if pressure fluctuations in a high pressure rail 26, 28, 30, 32 are below the predetermined magnitude, fluid flow between adjacent high pressure rails will be limited to flow through orifices 72, but when the fluctuations exceed the predetermined magnitude, greater fluid flow between the adjacent high pressure rails 26, 28 and 30, 32 is achieved by the opening of the check valve 70. The use of the Helmholz resonance isolation valves 62, 64, 66, 68 provides for a quick dissipation of pressure fluctuations that achieve a resonance within a high pressure rail 26, 28, 30, 32.

[0032] Fluid circuit 80 illustrated in Fig. 4 operates in a similar manner to the fluid circuit 10 of Fig. 1, except that limited flow between adjacent high pressure rails 26, 28, 30, 32 is replaced with limited flow between high pressure rails located on opposite sides of the engine via Helmholz resonance isolation valves 82, 84 located adjacent the high pressure pump assembly 20. Accordingly, high pressure rails 26, 28 located one side of the engine have limited fluid communication with the high pressure rails 30, 32 located on the other side of the engine through orifices 88. As with the fluid circuit of Fig. 2, the limited fluid flow across different sides of the engine may provide for a less rigid fluid circuit, thereby allowing pressure fluctuations in the high pressure rails 26, 28, 30, 32 to dissipate faster.

[0033] Finally, the operation of fluid circuit 90 allows fluid communication between each of the high pressure rails 26, 28, 30, 32 at the outlet of the high pressure pump assembly 20. Accordingly, pressure fluctuations emanating from a high pressure rail 26, 28, 30, 32 must travel along its individual supply line 92, 94, 96, 98 to the outlet of the pump assembly 20 and back out another of the supply lines 92, 94, 96, 98 before it influences another high pressure rail 26, 28, 30, 32. The extended flow path between high pressure rails 26, 28, 30, 32 reduces the effect of pressure fluctuations in one high pressure rail on another high pressure rail.

[0034] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. For example, the fluid system described herein may be used in connection with fluid systems other than the fuel system of an internal combustion engine. For example, the fluid system described herein may be used to pass high pressure working fluid through a series of fluid control valves other than the fluid control valves of a fuel injector. Such alternative fluid control valves could be associated with, for example, hydraulically driven intake and exhaust valves of a camless engine.

[0035] Further, the arrangements disclosed may be applied to various engine sizes, such as V-4, V-6, V-8 and V-16 engines. In a V-4 arrangement, four high pressure rails may be used, one for each of the injectors. Further, in a V-6 arrangement, three high pressure rails may be used with each rail connected to one, two or three fuel injectors. Further, among the various engine sizes, an equal or unequal number of injectors may be connected to individual high pressure rails. For example, a V-16 engine may include three high pressure rails on each side of the engine, with two of the rails connected to two fuel injectors and the third high pressure rail connected to four fuel injectors. It is intended that the specification and examples be considered as exemplary only, with a true scope of the invention being indicated by the following claims.

Claims

1. A fuel system for an internal combustion engine, comprising:

   at least four fuel injectors (12) for supplying fuel to corresponding combustion chambers of the engine;
   a pump assembly (20) in fluid communication with the fuel injectors and supplying working fluid to the fuel injectors; and
   at least three high pressure rails (26, 28, 30, 32) fluidly connected between the pump assembly and the at least four fuel injectors, at least one of the high pressure rails providing a fuel supply to at least two fuel injectors.

2. The fuel system of claim 1, wherein at least two of the at least four fuel injectors (12) are located on a first side of the engine, and at least two other of the at least four fuel injectors (12) are located on an opposite, second side of the engine, and
   the at least three high pressure rails (26, 28, 30, 32) include at least four high pressure rails, at least two of which (26, 28) are located on the first side of the engine and at least another two of which (30, 32) are located on the second side of the engine.

3. The fuel system of claim 2, wherein at least two high pressure rails are fluidly connected to one another by at least one bridge line (52) having an orifice (56) formed therein.

4. The fuel system of claim 3, wherein at least another two high pressure rails are fluidly connected to one another by at least one bridge line (54) having an orifice (56) formed therein.

5. The fuel system of claim 2, wherein at least two high pressure rails are fluidly connected to one another by at least one fluid connection having two Helmholz resonance isolation valves (62, 64).

6. The fuel system of claim 5, wherein at least another two high pressure rails are fluidly connected to one another by at least one fluid connection having two Helmholz resonance isolation valves (66, 68); and
   each Helmholz resonance isolation valve includes a check valve (70) and an orifice (72) in parallel flow paths.

7. The fuel system of claim 2, wherein at least two high pressure rails share a common working fluid supply line (22) extending from an outlet of the pump assembly (20), and
   at least another two high pressure rails share a common working fluid supply line (24) extending from an outlet of the pump assembly (20).

8. The fuel system of claim 2, wherein each of the at least four high pressure rails includes a separate supply line (92, 94, 96, 98) connecting the high pressure rail to an outlet of the pump assembly (20).

9. A method for reducing pressure fluctuations in a fuel system of an internal combustion engine, comprising:

   supplying working fluid from a high pressure pump assembly (20) to at least three high pressure rails (26, 28, 30, 32); and
   passing working fluid from each of the at least three high pressure rails to at least four fuel injectors (12) of the engine.

10. The method of claim 9, wherein the supplying of working fluid to at least three high pressure rails includes supplying working fluid to at least four high pressure rails (26, 28, 30, 32), at least two of which are located on a first side of the engine, and at least two other of which are located on an opposite, second side of the engine, and
    the passing of working fluid to the fuel injectors of the engine includes passing working fluid from the at least four high pressure rails to the fuel injectors of the engine.

11. The method of claim 10, further including fluidly connecting the at least two high pressure rails located on the first side of the engine with at least one bridge line (52) having an orifice (56) formed therein.

12. The method of claim 11, further including fluidly connecting the at least two high pressure rails located on the second side of the engine with at least one bridge line (54) having an orifice (58) formed therein.

13. The method of claim 10, further including fluidly connecting the at least two high pressure rails located on the first side of the engine with at least one connection having two Helmholz resonance isolation

valves (62, 64).

14. The method of claim 13, further including fluidly connecting the at least two high pressure rails located on the second side of the engine with at least one fluid connection having two Helmholz resonance isolation valves (66, 68); and
each Helmholz resonance isolation valve includes a check valve (70) and an orifice (72) in parallel flow paths.

15. The method of claim 9, wherein the supplying of working fluid to the at least three high pressure rails includes separately supplying working fluid to each high pressure rail through individual lines (92, 94, 96, 98) connecting each high pressure rail to an outlet of the pump assembly.

16. The method of claim 10, wherein said passing of working fluid from the at least four high pressure rails to the fuel injectors of the engine includes serially alternating the passing of working fluid to a fuel injector between each of the at least four high pressure rails.

Patentansprüche

1. Brennstoffsystem für einen Verbrennungsmotor, welches Folgendes aufweist:

mindestens vier Brennstoffeinspritzvorrichtungen (12) zum Liefern von Brennstoff zu entsprechenden Brennkammern des Motors;
eine Pumpenanordnung (20) in Strömungsmittelverbindung mit den Brennstoffeinspritzvorrichtungen, die Arbeitsströmungsmittel zu den Brennstoffeinspritzvorrichtungen liefern; und
mindestens drei Hochdruck-Rails (gemeinsame Druckleitungen) (26, 28, 30, 32), die strömungsmittelmäßig zwischen der Pumpenanordnung und den mindestens vier Brennstoffeinspritzvorrichtungen angeschlossen sind, wobei mindestens eine der Hochdruck-Rails eine Brennstoffversorgung zu mindestens zwei Brennstoffeinspritzvorrichtungen liefert.

2. Brennstoffsystem nach Anspruch 1, wobei mindestens zwei der mindestens vier Brennstoffeinspritzvorrichtungen (12) auf einer ersten Seite des Motors gelegen sind, und wobei mindestens zwei andere der mindestens vier Brennstoffeinspritzvorrichtungen (12) auf einer gegenüberliegenden zweiten Seite des Motors gelegen sind, und
wobei die mindestens drei Hochdruck-Rails (26, 28, 30, 32) mindestens vier Hochdruck-Rails aufweisen, wobei mindestens zwei (26, 28) davon auf der ersten Seite des Motors gelegen sind, und wobei mindestens zwei andere (30, 32) davon auf der zweiten Seite des Motors gelegen sind.

3. Brennstoffsystem nach Anspruch 2, wobei mindestens zwei Hochdruck-Rails strömungsmittelmäßig miteinander durch mindestens eine Brückenleitung (52) mit einer darin ausgeformten Zumessöffnung (56) verbunden sind.

4. Brennstoffsystem nach Anspruch 3, wobei mindestens zwei andere Hochdruck-Rails strömungsmittelmäßig miteinander durch mindestens eine Brükkenleitung (54) mit einer darin ausgeformten Zumessöffnung (56) verbunden sind.

5. Brennstoffsystem nach Anspruch 2, wobei mindestens zwei Hochdruck-Rails strömungsmittelmäßig miteinander durch mindestens eine Strömungsmittelverbindung mit zwei Helmholz-Resonanz-Isolationsventilen (62, 64) verbunden sind.

6. Brennstoffsystem nach Anspruch 5, wobei mindestens zwei weitere Hochdruck-Rails strömungsmittelmäßig miteinander durch mindestens eine Strömungsmittelverbindung mit zwei Helmholz-Resonanz-Isolationsventilen (66, 68) verbunden sind; und wobei jedes Helmholz-Resonanz-Isolationsventil ein Rückschlagventil (70) und eine Zumessöffnung (72) in parallelen Flusspfaden aufweist.

7. Brennstoffsystem nach Anspruch 2, wobei mindestens zwei Hochdruck-Rails eine gemeinsame Arbeitsströmungsmittelversorgungsleitung (22) verwenden, die sich von einem Auslass der Pumpenanordnung (20) erstreckt, und
wobei mindestens zwei andere Hochdruck-Rails eine gemeinsame Arbeitsströmungsmittelversorgungsleitung (24) haben, die sich von einem Auslass der Pumpenanordnung (20) erstreckt.

8. Brennstoffsystem nach Anspruch 2, wobei jede der mindestens vier Hochdruck-Rails eine getrennte Versorgungsleitung (92, 94, 96, 98) aufweist, welche die Hochdruck-Rail mit einem Auslass der Pumpenanordnung (20) verbindet.

9. Verfahren zur Verringerung von Druckfluktuationen in einem Brennstoffsystem eines Verbrennungsmotors, welches Folgendes aufweist:

Liefern von Arbeitsströmungsmittel von einer Hochdruckpumpenanordnung (20) zu mindestens drei Hochdruck-Rails (26, 28, 30, 32); und
Leiten von Arbeitsströmungsmittel von jeder der mindestens drei Hochdruck-Rails zu mindestens vier Brennstoffeinspritzvorrichtungen (12) des Motors.

10. Verfahren nach Anspruch 9, wobei das Liefern von Arbeitsströmungsmittel zu mindestens drei Hochdruck-Rails aufweist, Arbeitsströmungsmittel zu mindestens vier Hochdruck-Rails (26, 28, 30, 32) zu liefern, wobei mindestens zwei davon auf einer ersten Seite des Motors gelegen sind, und wobei mindestens zwei andere davon auf einer gegenüberliegenden zweiten Seite des Motors gelegen sind, und wobei das Leiten des Arbeitsströmungsmittels zu den Brennstoffeinspritzvorrichtungen des Motors aufweist, Arbeitsströmungsmittel von den mindestens vier Hochdruck-Rails zu den Brennstoffeinspritzvorrichtungen des Motors zu leiten.

11. Verfahren nach Anspruch 10, welches weiter aufweist, strömungsmittelmäßig die mindestens zwei Hochdruck-Rails zu verbinden, die auf der ersten Seite des Motors gelegen sind, und zwar mit mindestens einer Brückenleitung (52), die eine darin ausgeformte Zumessöffnung (56) hat.

12. Verfahren nach Anspruch 11, welches weiter aufweist, strömungsmittelmäßig die mindestens zwei Hochdruck-Rails zu verbinden, die auf der zweiten Seite des Motors gelegen sind, und zwar mit mindestens einer Brückenleitung (54), mit einer darin ausgeformte Zumessöffnung (58).

13. Verfahren nach Anspruch 10, welches weiter aufweist, strömungsmittelmäßig die mindestens zwei Hochdruck-Rails zu verbinden, die auf der ersten Seite des Motors gelegen sind, und zwar mit mindestens einer Verbindung, die zwei Helmholz-Resonanz-Isolationsventile (62, 64) hat.

14. Verfahren nach Anspruch 13, welches weiter aufweist, strömungsmittelmäßig die mindestens zwei Hochdruck-Rails, die auf der zweiten Seite des Motors gelegen sind, mit mindestens einer Strömungsmittelverbindung zu verbinden, die zwei Helmholz-Resonanz-Isolationsventile (66, 68) hat; und wobei jedes Helmholz-Resonanz-Isolationsventil ein Rückschlagventil (70) und eine Zumessöffnung (72) in parallelen Flusspfaden aufweist.

15. Verfahren nach Anspruch 9, wobei das Liefern von Arbeitsströmungsmittel zu den mindestens drei Hochdruck-Rails aufweist, getrennt Arbeitsströmungsmittel zu jeder Hochdruck-Rail durch einzelne Leitungen (92, 94, 96, 98) zu liefern, die jede Hochdruck-Rail mit einem Auslass der Pumpenanordnung verbinden.

16. Verfahren nach Anspruch 10, wobei das Leiten von Arbeitsströmungsmittel von den mindestens vier Hochdruck-Rails zu den Brennstoffeinspritzvorrichtungen des Motors aufweist, das Leiten von Arbeitsströmungsmittel zu einer Einspritzvorrichtung zwischen jeder der mindestens vier Hochdruck-Rails seriell abzuwechseln.

Revendications

1. Système d'injection pour moteur à combustion interne, comprenant :

au moins quatre injecteurs de carburant (12) pour fournir du carburant à des chambres de combustion correspondantes du moteur ;
une structure de pompe (20) en communication avec les injecteurs de carburant pour fournir un fluide d'actionnement aux injecteurs de carburant ; et
au moins trois distributeurs haute pression (26, 28, 30, 32) reliés entre la structure de pompe et lesdits au moins quatre injecteurs de carburant, au moins un des distributeurs haute pression fournissant une alimentation en carburant à au moins deux injecteurs de carburant.

2. Système d'injection selon la revendication 1, dans lequel au moins deux desdits au moins quatre injecteurs de carburant (12) sont disposés d'un premier côté du moteur et au moins deux autres desdits au moins quatre injecteurs de carburant (12) sont disposés d'un second côté, opposé, du moteur ; et lesdits au moins trois distributeurs haute pression (26, 28, 30, 32) incluent au moins quatre distributeurs haute pression, dont au moins deux (26, 28) sont disposés du premier côté du moteur et au moins deux autres (30, 32) sont disposés du second côté du moteur.

3. Système d'injection selon la revendication 2, dans lequel au moins deux distributeurs haute pression sont connectés l'un à l'autre par au moins une conduite de liaison (52) dans laquelle est formé un orifice (56).

4. Système d'injection selon la revendication 3, dans lequel au moins deux autres distributeurs haute pression sont connectés l'un à l'autre par au moins une conduite de liaison (54) dans laquelle est formé un orifice (56).

5. Système d'injection selon la revendication 2, dans lequel au moins deux distributeurs haute pression sont connectés l'un à l'autre par au moins une connexion de fluide comprenant deux vannes d'isolement à résonateur de Helmholtz (62, 64).

6. Système d'injection selon la revendication 5, dans lequel au moins deux distributeurs haute pression sont connectés l'un à l'autre par au moins une connexion de fluide comprenant deux vannes d'isolement à résonateur de Helmholtz (66, 68) ; et chaque vanne d'isolement à résonateur de Helmholtz comprend un clapet anti-retour (70) et un orifice (72) dans des trajets d'écoulement parallèles.

7. Système d'injection selon la revendication 2, dans lequel :

au moins deux distributeurs haute pression partagent une ligne d'alimentation de fluide d'actionnement commune (22) s'étendant à partir d'une sortie de la structure de pompe (20) ; et
au moins deux autres distributeurs haute pression partagent une ligne d'alimentation de fluide d'actionnement commune (24) s'étendant à partir d'une sortie de la structure de pompe (20).

8. Système d'injection selon la revendication 2, dans lequel chacun desdits au moins quatre distributeurs haute pression comprend une ligne d'alimentation séparée (92, 94, 96, 98) reliant le distributeur haute pression à une sortie de la structure de pompe (20).

9. Procédé de réduction des fluctuations de pression dans un système d'injection d'un moteur à combustion interne comprenant :

fournir un fluide d'actionnement à partir d'une structure de pompe haute pression (20) à au moins trois distributeurs haute pression (26, 28, 30, 32) ; et
faire passer le fluide d'actionnement à partir de chacun desdits au moins trois distributeurs haute pression vers au moins quatre injecteurs de carburant (12) du moteur.

10. Procédé selon la revendication 9, dans lequel :

la fourniture de fluide d'actionnement à au moins trois distributeurs haute pression comprend la fourniture de fluide d'actionnement à au moins quatre distributeurs haute pression (26, 28, 30, 32) dont au moins deux sont disposés d'un premier côté du moteur et au moins deux autres sont disposés d'un second côté opposé du moteur ; et
le passage de fluide d'actionnement vers les injecteurs de carburant du moteur inclut le passage de fluide d'actionnement vers au moins quatre distributeurs haute pression vers les injecteurs de carburant du moteur.

11. Procédé selon la revendication 10, comprenant en outre l'étape consistant à relier lesdits au moins deux distributeurs haute pression disposés du premier côté du moteur à au moins une conduite de liaison (52) dans laquelle est formé un orifice (56).

12. Procédé selon la revendication 11, comprenant en outre l'étape consistant à relier lesdits au moins deux distributeurs haute pression disposés du second côté du moteur à au moins une conduite de liaison (54) dans laquelle est formé un orifice (58).

13. Procédé selon la revendication 10, comprenant en outre l'étape consistant à relier lesdits au moins deux distributeurs haute pression disposés du premier côté du moteur à au moins une connexion de fluide comprenant deux vannes d'isolement à résonateur de Helmholtz (62, 64).

14. Procédé selon la revendication 13, comprenant en outre l'étape consistant à connecter l'un à l'autre lesdits au moins deux distributeurs haute pression par au moins une connexion de fluide comprenant deux vannes d'isolement à résonateur de Helmholtz (66, 68) ; et dans lequel chaque vanne d'isolement à résonateur de Helmholtz comprend un clapet anti-retour (70) et un orifice (72) dans des trajets d'écoulement parallèles.

15. Procédé selon la revendication 9, dans lequel la fourniture de fluide d'actionnement à au moins deux distributeurs haute pression comprend la fourniture séparée de fluide d'actionnement à chaque distributeur haute pression par des lignes d'alimentation individuelles (92, 94, 96, 98) reliant chaque distributeur haute pression à une sortie de la structure de pompe.

16. Procédé selon la revendication 10, dans lequel le passage de fluide d'actionnement à partir desdits au moins quatre distributeurs haute pression vers les injecteurs de carburant du moteur comprend le fait d'alterner en série le passage de fluide d'actionnement vers un injecteur de carburant entre chacun desdits au moins quatre distributeurs haute pression.

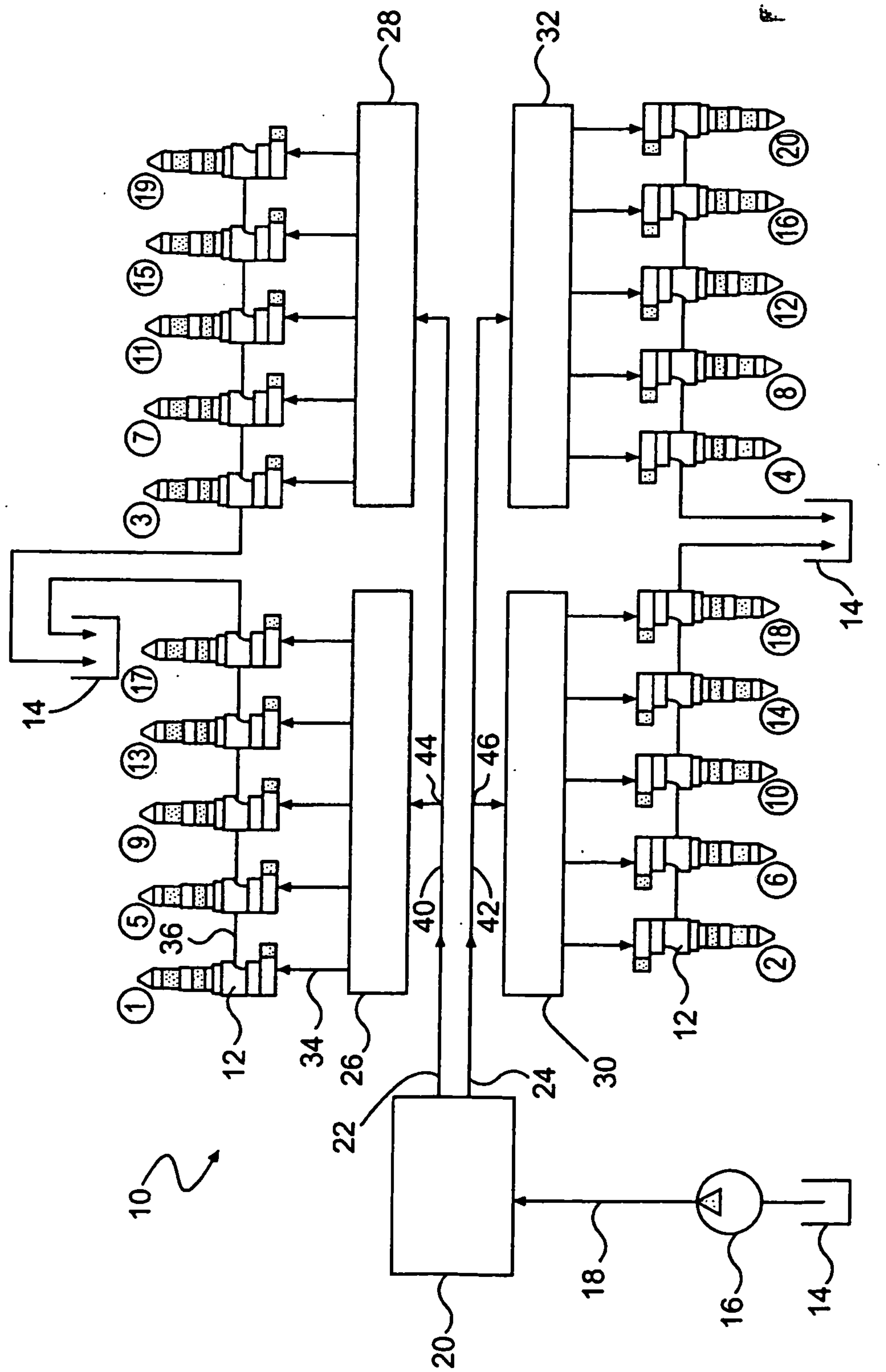
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FIG. 1

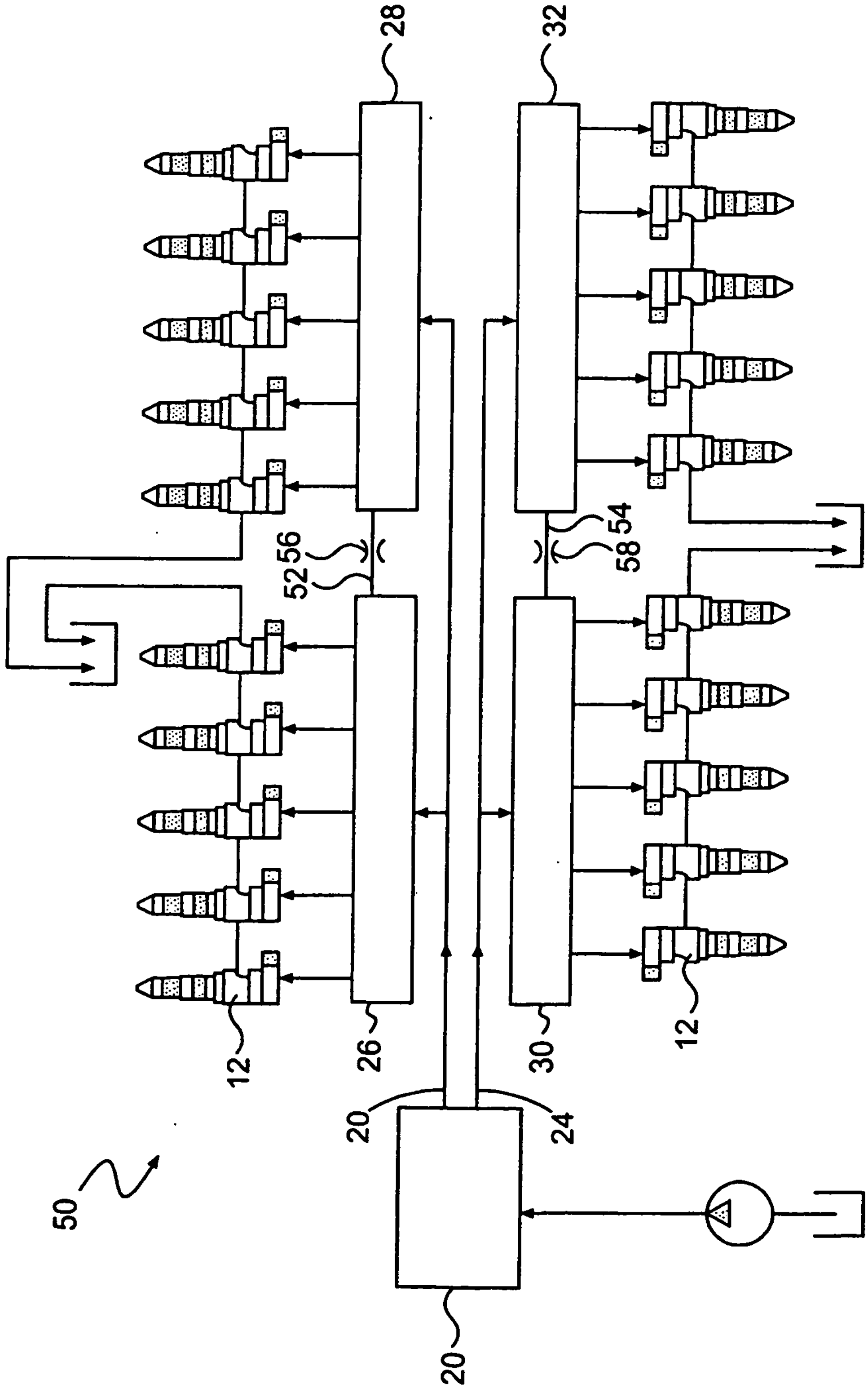

FIG. 2

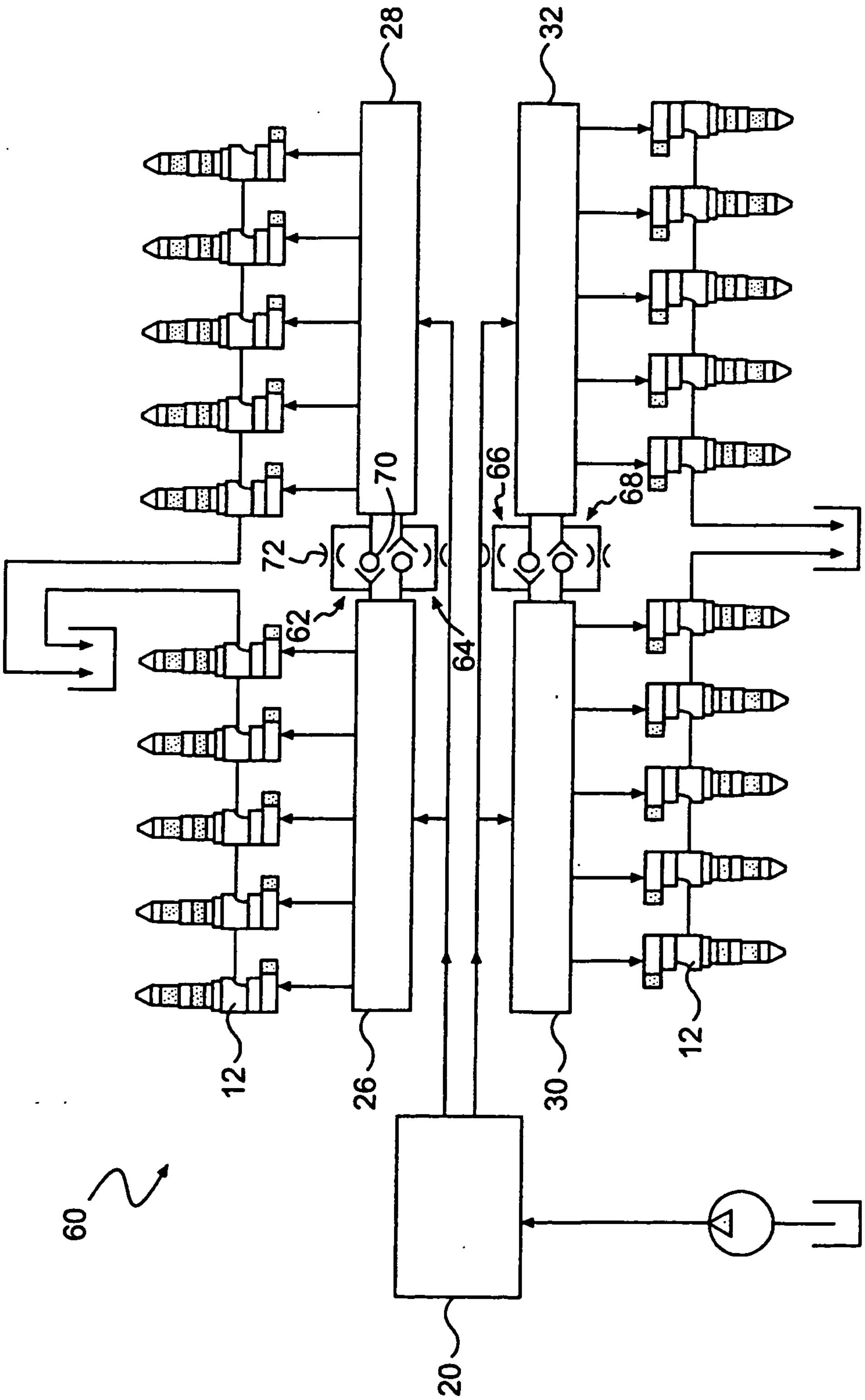

FIG. 3

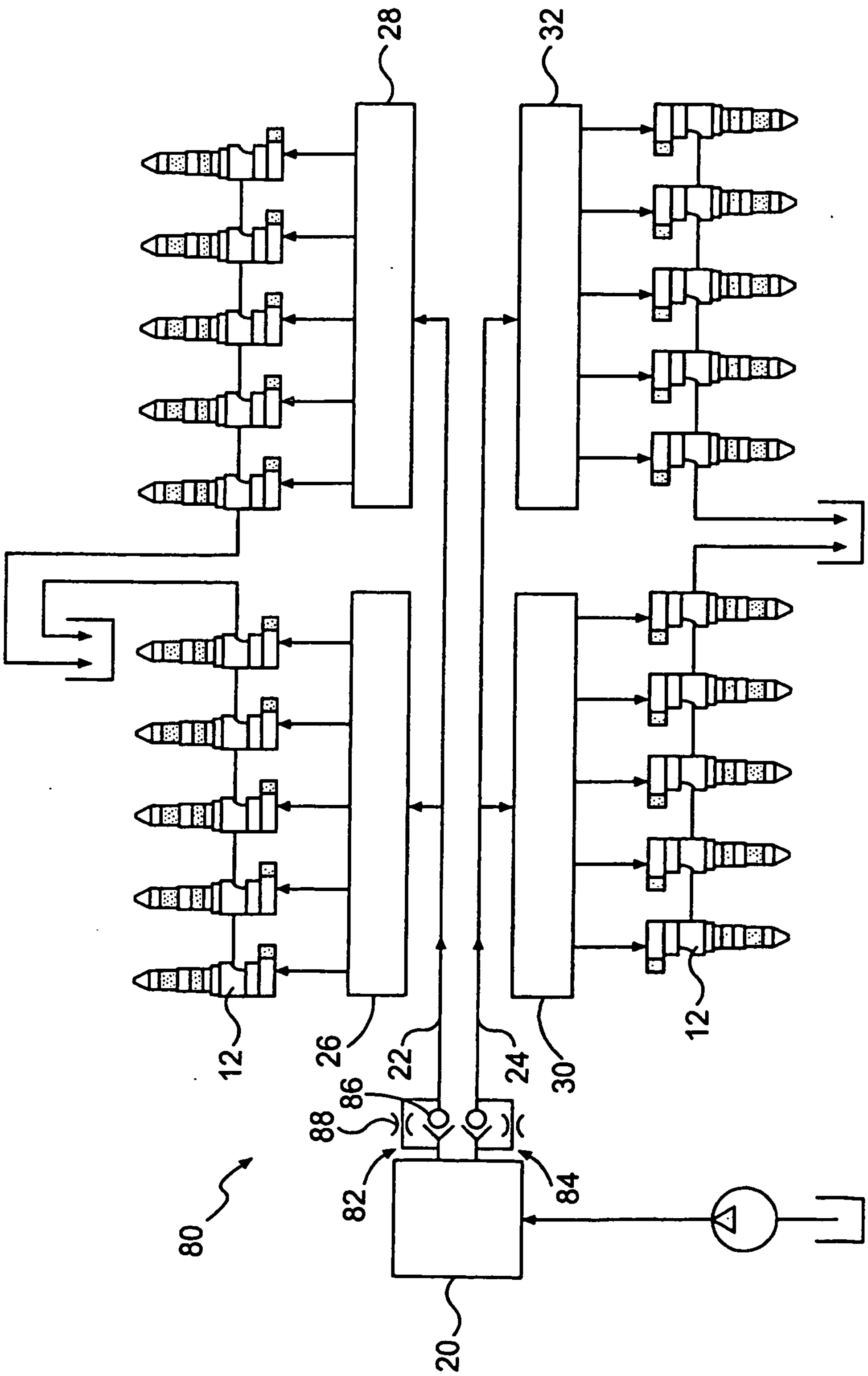

FIG. 4

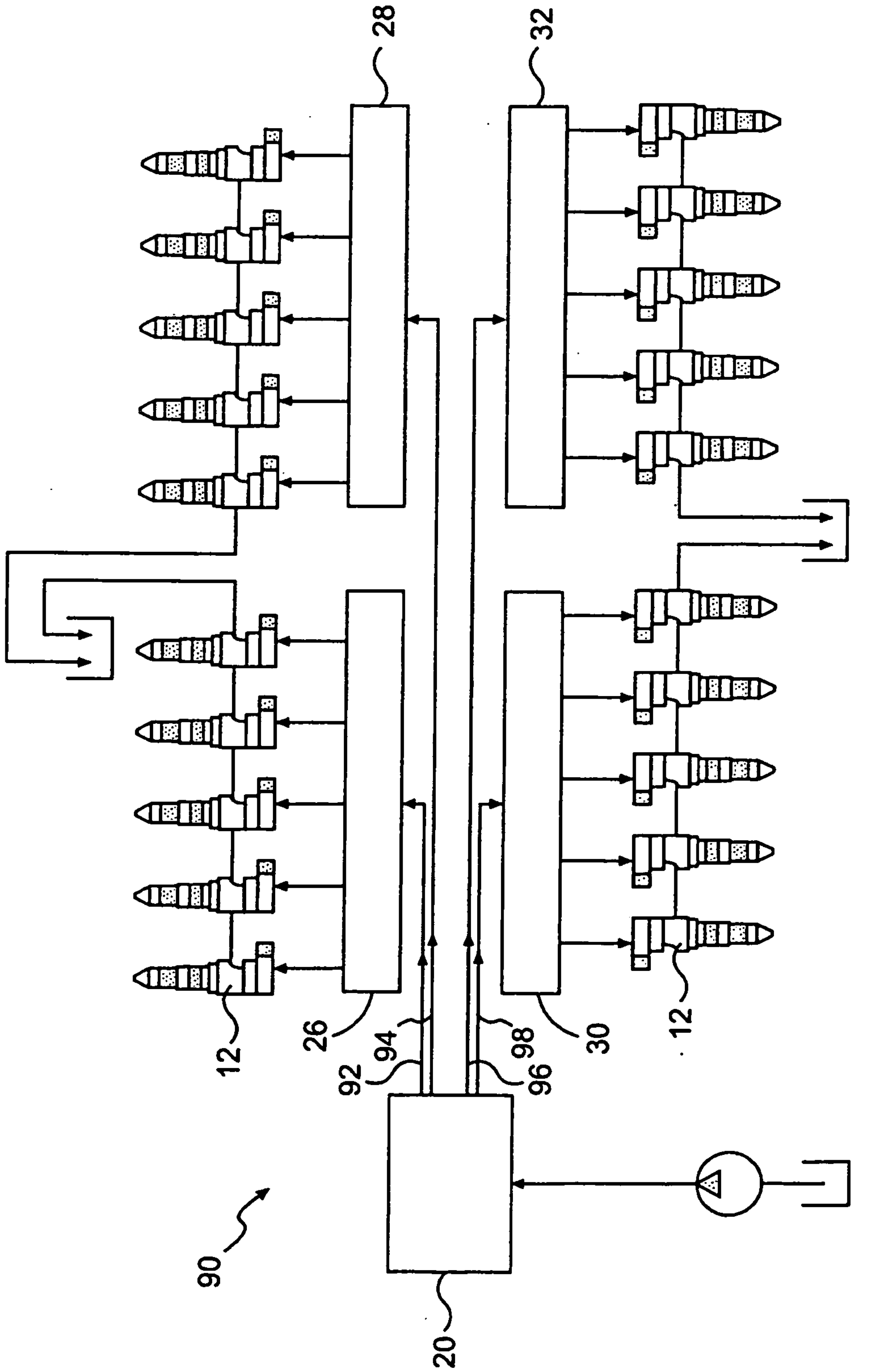

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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